NAL PROPOSAL No. 0073

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PROPOSAL TO MEASURE TWO BODY ELASTIC AND QUASI-ELASTIC SCATTERING AT HIGH ENERGIES

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ABSTRACT

It is proposed to measure two body elastic scattering in the t and u-channel for $p, \bar{p}, K^+, K^-, \pi^+, \pi^-$ using a focusing spectrometer in coincidence with a counter-hodoscope system. t-channel reactions should be measurable up to 150 GeV, and u-channel processes up to 75 GeV.

* Work supported by the U.S. Atomic Energy Commission.

Introduction

A number of the N.A.L. summer studies(1-8) were devoted to two body scattering reactions in the t and u-channels of the form

$$X + p \rightarrow X + p \qquad \text{or} \qquad X + n \rightarrow X + n$$

where

$$X \text{ is } \pi^{\pm},\ K^{\pm},\ p \text{ or } \bar{p}$$

In the past such reactions have been studies up to energies of the order of 25 GeV in the t-channel and up to 15 GeV in the u-channel. At N.A.L. it should be relatively easy to measure t-channel processes up to energies in excess of 150 GeV, and u-channel processes up to energies of 75 GeV or possibly higher.

The motivation for such studies is well known. The cross sectional dependence can be empirically expressed as proportional to $S^{\alpha(t)}$, where S is the C. of M. energy squared and $\alpha(t)$ is the "Regge" parameter. The behaviour of $\alpha(t)$ is one of the most important inputs into all theories concerned with high energy processes. At high energies these processes should be dominated by "leading trajectories (or terms)" and are expected to display particularly simple features. In the t-channel, pomeron-exchange or diffraction scattering should dominate and particle anti-particle scattering should become identical at high energies. Tentative Serpukov results have led to questioning the point at which this Pomeranchuk limit occurs. Even if these tentative Serpukov results prove to be incorrect, the differential cross sections and their energy dependence will be of great interest.

To measure these scattering reactions we propose to set up (and/or use) a flexible "on-line" horizontal bend focussing spectrometer system(6) to measure the high energy outgoing particles from two body scattering in coincidence with scintillator and wire chamber hodoscopes to define the angle and origin of the slow outgoing secondary particles. Fig. 1 shows a schematic of the apparatus. Rejection of unwanted inelastic processes would be based on the resolution properties of the high energy spectrometer plus coplanaraity and angular requirements. The focussing spectrometer would also be extremely well adapted to making initial beam surveys. Our proposal is based on the assumption that "spectrometer" facilities of the required type(s) will come into existance at N.A.L. We would also expect that similar proposals to ours will be made, and that the various groups will have to accommodate to some reasonable degree of cooperation. Our group at this moment is insufficiently staffed and financed to take over complete responsibility for the program in this proposal. However, we believe that if this proposal is the only one approved in this area of physics, that we would obtain the required personnel and support to carry this program through. We have not made a detailed manpower estimate. However the program is very similar in scope to the spectrometer programs we have been associated with at S.L.A.C. and can be measured as being equivalent to one "S.L.A.C. unit".

Required Measurement Precision

We are proposing to measure all parameters of the "fast" outgoing particle, in coincidence with the production angle of the slow outgoing particle. These measurements would overconstrain two body reactions by three constraints. We would make the following "cuts" on the data:

1) Measurement of the momenta of the outgoing fast particle, would define the missing mass of the slow particle. At worst an appropriate momentum cut should include a very small fraction of events in which the slow outgoing particles are accompanied by single slow π-mesons.

2) Coplanarity would be required between the incoming particle and the two outgoing particles.

3) Correct kinematic relationships would be required between the production angles of the slow and fast particles.

4) Identification of the mass of the fast outgoing particle would be made with Cerenkov counters.

t-channel processes will almost certainly be so dominated by the diffraction processes that we would expect either cut (1) (the measurement of momentum), or cuts (2) and (3) alone to provide sufficient rejection against unwanted events. We have in fact done high-energy photoproduction experiments relying on a single arm spectrometer, and one of us (D.M.R.) has been associated with a University College/Rutherford Laboratory collaboration which has just measured K^+p elastic scattering relying only on angular information.

u-channel reactions would make use of the same four cuts. As a rough guide, we note that the precisions required are:

For cut 1: $\frac{\Delta p}{p_o} \lesssim \frac{\Delta(M.M.)}{p_o}$ where (M.M.) is the missing mass, and p_o is the incident beam momentum. Lower precision would still lead to a very substantial rejection of unwanted events. We propose to operate with precisions in the neighborhood of 0.1% accuracy or better for $\Delta p/p_o$.

For cut 2: $\Delta\phi$, the error in the determination of the azimuthal production angle of the fast particle, is related to p_τ, the C. of M. momentum of the unobserved pion (the C. of M. system is that of the slow particle and the unobserved pion), by:

$$\Delta\phi \lesssim p_\tau/p_o$$

The azimuthal production angle of the slow particle is trivially measured to the required precision. We propose to have azimuthal angular precision of the order of 0.1 milliradians for the fast particle.

For cut 3: $\Delta\theta$, the error in production angle of the slow particle, should be $\lesssim p_T/p_{slow}$. At typical t or u values the momentum p_{slow} of the slow outgoing particle would lie between 400 MeV/c and 2.0 BeV/c and measurements good to 1.5° would provide excellent rejection. We propose angular precision good to $\sim 1^\circ$.

After making the above cuts on the data we would expect to have a very clean sample of two body events. The t or u values are well defined for this sample from the production angle θ of the outgoing slow particle. As a rough guide

$$|u| \approx M_p^2 \left(\frac{1 + \cos\theta}{1 - \cos\theta}\right) \quad \text{(analytical result)}$$

$$|t| \approx \left[\frac{(90^\circ - \theta^\circ)}{29}\right]^{2.5} \quad \text{(empirical result taken from kinematic tables)}$$

The proposed angular precision of 1° ensures a measurement of t to better than $0.1(\text{BeV/c})^2$ over the whole range of interest. We would expect this system also to be able to measure quasi two body reactions in a second round of measurements.

<u>Philosophy of Measurement</u>

We propose a backbone of "coarse-grained" scintillation hodoscopes on both detector arms. The fast scintillator resolving times would make them resistant to background. At the largest possible $|t|$ and $|u|$ values we would expect this system to provide enough precision to give adequate identification and to enable us to use the fullest available input beam intensities of $\sim 3 \times 10^8$ particles per burst. For the high momentum spectrometer, coarse grained hodoscopes would be located at the momentum focus (20 counters each spanning 0.1% $\Delta p/p$) and at the angular measurement positions (20 counters each with a precision of 0.5 milliradians).

For the slow particles we would cover a solid angle of 1/2 steradian. We would use a bank of 20 horizontal counters located 2 ft. from the target to define the azimuthal production angle. To define the horizontal production angle to a precision of 1° we would use two banks of vertical picket fence counters consisting of 50 and 100 counters located at 3 ft. and 6 ft. respectively from the target. Fig. 1 shows a schematic of the setup. We would expect to be able to analyze "on-line" with this coarse-grained system.

This backbone system would be spanned by large trigger scintillators S_1, S_2, S_3, S_4 (c.f. Fig. 1) to provide the interrogation pulse. In addition we would add wire chamber planes which could be used to provide "fine grain" measurement precision.

The counters would be connected to an on-line computer and the data would be analyzed on a real time basis.

Spectrometer Optics and Instrumentation

The spectrometer optics are at present being actively studied by N.A.L.[10] At present no hard decisions have been made.

For the purposes of this proposal we append the design parameters of a partially optimised 75 GeV setup, which would be very well suited for these measurements. The potential precision of the device is well above that required to make a clean separation of two body events.

From our experience at the S.L.A.C. we believe that it will probably be considerably more convenient to mount this spectrometer (about 90 meters long) on a rotatable carriage, than to change the input beam angle and leave the spectrometer fixed.

The question immediately comes up as to the feasibility of rotating a magnet-counter system of 90 meters length with the precision necessitated by this proposal. As a good example of such a rotating support system, one need only turn to the S.L.A.C. 20 GeV spectrometer which is 50 meters in length. The alignment tolerances on the S.L.A.C. spectrometer are comparable with those we require. In general at S.L.A.C. an alignment of ± 0.003 to 0.005 inches is maintained over the entire length. A roll angle of less than $\pm 2 \times 10^{-5}$ radians is maintained on the individual elements. If necessary, alignment would be maintained with a laser optical system.

Besides the scintillation and wire chamber systems we would expect to use a differential Cerenkov counter to differentiate pions from kaons in the central spectrometer region where the beam is rendered parallel by the optics.

We would expect beam divergences in the non-bend plane of the order of ± 0.3mr corresponding to spot sizes at the target of ± 1mm for a 75 GeV spectrometer with 75 micro-steradians acceptance. At 150 GeV we would expect about 25 micro-steradians acceptance and the divergences would be about ± 0.1mr.

In the bend plane the sensitivity to spot sizes is about a factor of ten less. Therefore problems will not occur due to apparent spot sizes until production angles in excess of 20 milliradians are reached, even with a 20" long target. For diffraction scattering we believe we will obtain sufficient rejection to make measurements, even out to the highest $|t|$ values that can be reached. This will be particularly important to check hypotheses such as the Drell hypothesis that "contact" terms become dominant.

We would propose the following Cerenkov counter characteristics[11] to separate pions from kaons: (c.f., Fig. 2 for a schematic of the counter)

At 75 GeV

Length	10 meters
Cerenkov angle	12 milliradians
No. of photoelectrons	7
Angular separation of pions from kaons	2 milliradians

At 150 GeV

Length	15 meters
Cerenkov angle	8mr
No. of photoelectrons	5
Angular separation of pions and kaons	0.7mrs

Expected Rates

Expected cross sections for the t-channel are given in Table I in terms of $d\sigma/dt = Ae^{Bt}$

Table I: Elastic Cross Sections

Process	σ_{tot} (mb)	A (mb/GeV^2)	B (GeV^{-2})	$\sigma_{Elastic}$ (mb)	Comment
$p + p$	40	80	8	10	Falling slowly
$\pi + p$	25	32	9	3.5	Constant
$K + p$	22	25	8	3.1	Constant
$\bar{p} + p$	52	135	9	14	Falling slowly

Expected cross sections in the u-channel can be approximately represented by

$$\left(\frac{d\sigma}{du}\right)_{u=0} = \frac{300}{E^2} \ \mu b/GeV^2.$$

We tabulate counting rates per hour for small u and t. (In actual fact full beam intensities would not be used and counting rates would be held to about 10 to 10^2 counts per burst.)

Table II: Rates at 75 GeV

We assumed a solid angle acceptance of the high energy spectrometer of 75 micro-steradians and a 20" liquid hydrogen target.

Process	Beam Intensity per burst	"counts/hour" at small t or u	No. of decades over which cross section can be measured
		t-channel	
p p	10^8	6.3×10^9	8.5
$\pi^{\pm}$ p	10^8	2.5×10^9	8
K^+ p	10^7	2.0×10^8	7
K^- p	10^6	2.0×10^7	6
$\bar{p}$ p	10^6	2.0×10^7	6
		u-channel	
$\pi^{\pm}$ p	10^7	4×10^3	2.5
K^+ p	10^7	4×10^2	1.5

Table III: Rates at 150 GeV

Assumed solid angle acceptance of the high energy spectrometer, 25 micro-steradians

Process	Beam Intensity Per Burst	"counts/hour" at small t or u	No. of decades over which cross section can be measured
		t-channel	
p p	10^8	5×10^9	8.5
$\pi^{\pm}$ p	10^8	2×10^9	8.0
K^+ p	10^7	1.5×10^8	7.0
K^- p	10^6	1.5×10^7	5.5
$\bar{p}$ p	10^6	1.5×10^7	1.5
		u-channel	
$\pi^{\pm}$ p	10^8	2×10^2	1.0

Running Time Estimates

We would expect to measure t-channel reactions at 25 GeV (to tie onto existing data), 50 GeV, 75 GeV, 100 GeV and 150 GeV. Each energy would take about 20 hours to complete, giving a total time for a first survey of 100 hours per particle. To survey $p^{\pm}$, $\pi^{\pm}$, and $K^{\pm}$ we would then require 600 hours of running time.

For u-channel reactions we would run at 25, 50, 75, and 125 GeV for π^{+}, π^{-}, with about 25 hours for each run. For $K^{\pm}$ we would run at 25, 50, and 75 GeV only, and for $\bar{p}$ at 25 and 50 GeV requiring 325 hours.

If, as seems probable, the high energy spectrometer had sufficient precision on its own to measure a substantial range of t values, we would like to repeat some of the $p^{\pm}$, $\pi^{\pm}$, and $K^{\pm}$ runs at 25, 75, and 150 GeV with a deuterium target. As $|t| = 2 E_i E_f (1 - \cos \theta)$, where E_i and E_f are the initial and final energies and θ the production angle, the measurement of $|t|$ is unaffected by Fermi motion, and it should be easily possible to measure neutron diffraction scattering. These measurements would require a further 250 hours.

Apparatus

We would require liquid hydrogen and deuterium targetry, spectrometer powering, and a control computer of PDP-8 capacity. The actual spectrometer cost should be in the range of \$500K[6].

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3. G. Manning, CERN/ECFA 67/16, Vol. I, 1967, p. 253.

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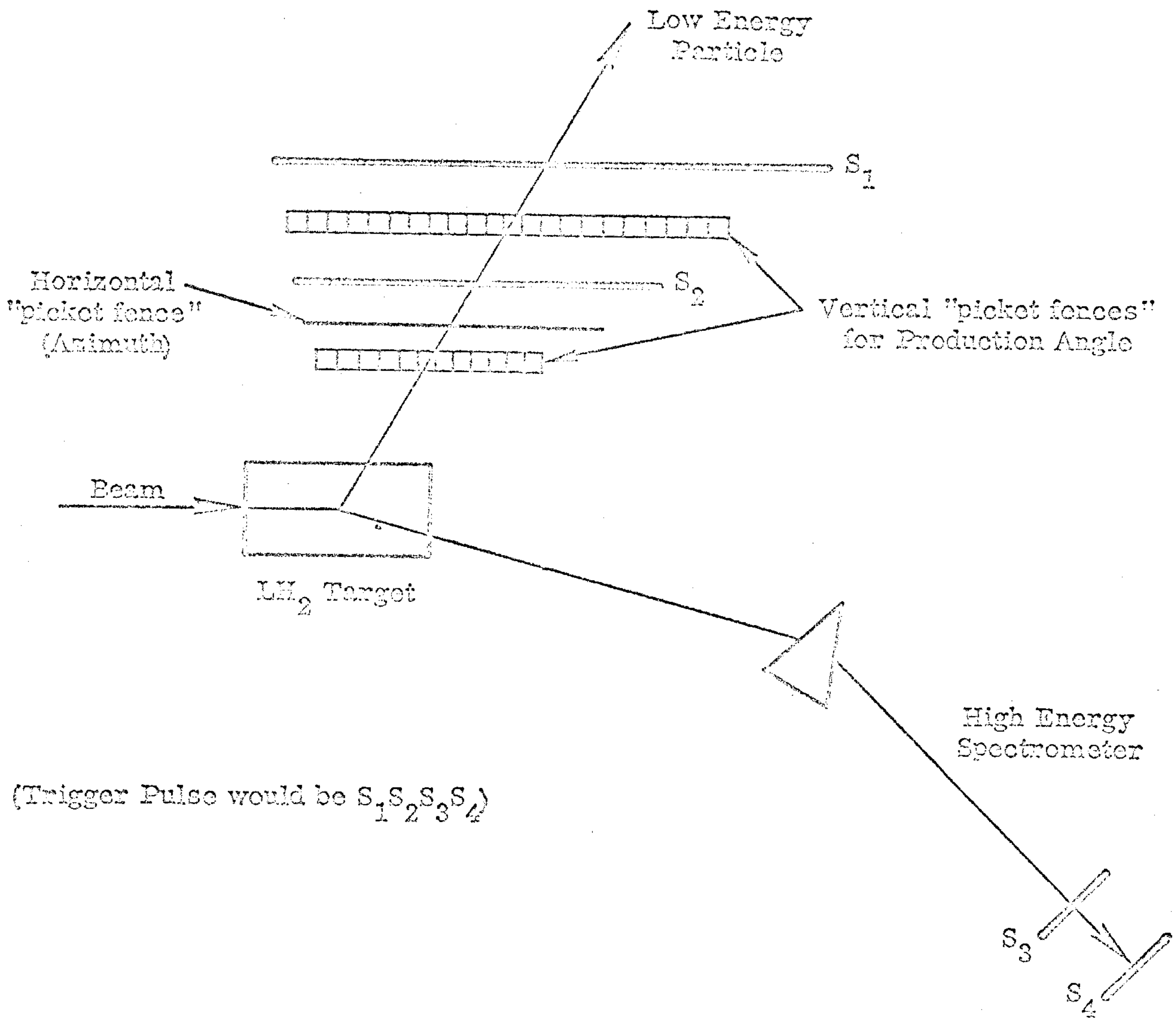

FIG. 1--Schematic of detection system.

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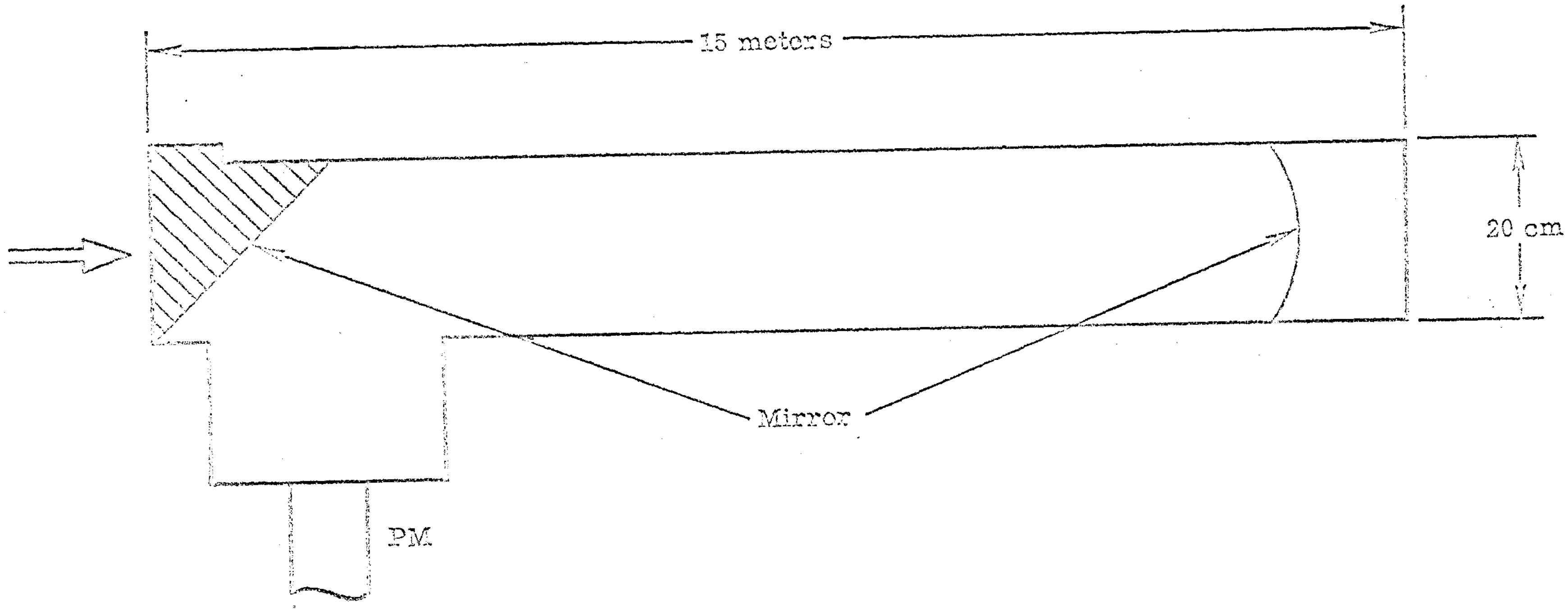

FIG. 2--Schematic of a large differential Cerenkov counter.

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APPENDIX 1

Components of a 75 GeV Spectrometer

	Meters	Meters from target
DRIFT	6.0	6.0
QUAD Q1	3.4 , 10 Kgauss, 10 cms radius	9.4
DRIFT	22	31.4
QUAD Q2	1.4 , 8 Kgauss, 10 cms radius	32.8
DRIFT	2	34.8
BEND M1	10 , 20 Kgauss	44.8
DRIFT	6	50.8
QUAD Q3	1.4 , 8 Kgauss, 10 cms radius	52.2
DRIFT	22	74.2
QUAD Q4	3.4 , 10 Kgauss, 10 cms radius	77.6
DRIFT	6.0	83.6

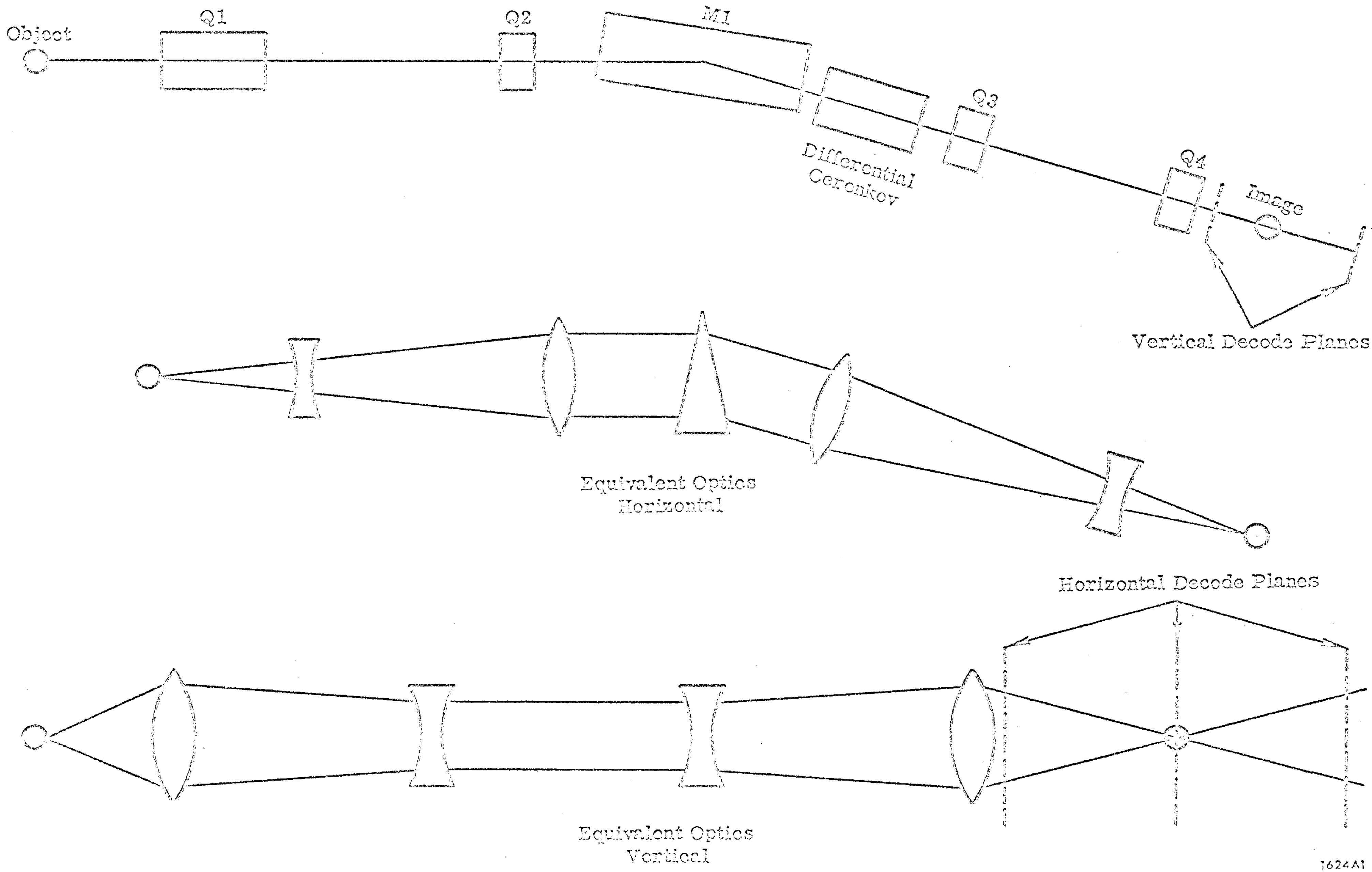
MOMENTUM DISPERSION - 4.5 cms per % $\Delta p/p$

HORIZ. AND VERTICAL MAGN. - 1

RATIO OF VERT. to HORIZ. ACCEPTANCE 8:1

SOLID ANGLE - 75 μ-steradians

Layout of High Resolution 75 GeV Spectrometer
(~ 75 μsr Acceptance)



APPENDIX 2

Some Representative Kinematics for $\pi p \to \pi p$ Elastic Scattering in the t-Channel

The spectrometer angle Θ, $dt/d\Omega_{lab}$, the sensitivity factors $(\partial MM^2/\partial\Theta)_p$, and $p(\partial MM^2/\partial p)_\Theta$ are tabulated for input beam momenta of 75 BeV/c and 150 BeV/c versus u for both the pion and proton. HMAG is the ratio of $(d\Theta_p/d\Theta_\pi)$ for the two lab production angles and VMAG is the ratio of the corresponding $(d\phi_p/d\phi_\pi)$ for the lab azimuthal angles.

A. Beam Momentum 75 GeV/c

	Θ degrees	$dt/d\Omega_{lab}$ BeV^2/sr	$(\partial MM^2/\partial\Theta)_p$ BeV^2/r	$p(\partial MM^2/\partial p)_\Theta$ BeV^2
	1. t = -0.1	VMAG = 232.4	HMAG = 33.12	
π	0.241	1788	47.4	-140.7
p	78.6	0.232	55.8	-10.46
	2. t = -0.5	VMAG = 98.4	HMAG = 33.7	
π	0.541	1778	105.8	-140.7
p	68.3	0.535	109.9	-33.4
	3. t = -1.0	VMAG = 65.4	HMAG = 30.4	
π	0.766	1765	149.4	-140.7
p	64.1	0.885	152.3	-52.9
	4. t = -1.5	VMAG = 50.5	HMAG = 27.5	
π	0.940	1752	182.7	-140.7
p	56.0	1.260	185.0	-66.5

B. Beam Momentum 150 GeV/c

	θ degrees	$dt/d\Omega/_{lab}$ BeV^2/sr	$(\partial MM^2/\partial\theta)_p$ BeV^2/r	$p(\partial MM^2/\partial p)_\theta$ BeV^2
	1. t = -0.1	VMAG = 466.1	HMAG = 65.5	
π	0.120	7158	94.6	-281
p	78.7	0.234	111.8	-20.76
	2. t = -0.5	VMAG = 197.2	HMAG = 67.0	
π	0.270	7137	211.8	-281
p	68.5	0.539	220.0	-66.4
	3. t = -1.0	VMAG = 131.3	HMAG = 60.7	
π	0.382	7112	299	-281
p	61.3	0.891	305	-105.1
	4. t = -1.5	VMAG = 101.6	HMAG = 54.9	
π	0.469	7087	366	-281
p	56.3	1.268	371	-132.1
	5. t = 1.9	VMAG = 86.8	HMAG = 51.0	
π	0.528	7066	412	-281
p	53.1	1.59	416	-148.4

APPENDIX 3

Some Representative Kinematics for $\pi p \to \pi p$ Elastic Scattering in the u-Channel

A. Beam Momentum 75 GeV/c

	θ degrees	$dt/d\Omega_{lab}$ BeV^2/sr	$(\partial MM^2/\partial\theta)_p$ BeV^2/r	$p(\partial MM^2/\partial p)_\theta$ BeV^2
	1. u = -0.1	VMAG = 146.4	HMAG = 146.2	
π	140.8	0.0845	48.6	-139.2
p	0.246	1810	48.7	-140.7
	2. u = -0.5	VMAG = 102.5	HMAG = 101.5	
π	104.4	0.172	106.4	-136.8
p	0.540	1800	106.4	-140.7
	3. u = -1.0	VMAG = 74.7	HMAG = 73.9	
π	85.0	0.383	149.8	-137.8
p	0.764	1787	149.8	-140.7
	4. u = -1.5	VMAG = 58.7	HMAG = 58.1	
π	73.7	0.519	183.0	-139.4
p	0.93	1775	183.0	-140.7
	5. u = -1.9	VMAG = 50.0	HMAG = 49.6	
π	67.3	0.709	205.6	-138.7
p	1.055	1765	205.6	-140.7

APPENDIX 3 - (continued)

B. Beam Momentum 150 GeV/c

	θ degrees	$dt/d\Omega_{lab}$ BeV^2/sr	$(\partial MM^2/\partial\theta)_p$ BeV^2/r	$p(\partial MM^2/\partial p)_\theta$ BeV^2
	1. u = -0.1	VMAG = 292	HMAG = 291	
π	141.45	0.0845	96.0	-270.5
p	0.122	7202	96.2	-281.5
	2. u = -0.5	VMAG = 205	HMAG = 202	
π	104.8	0.1727	212	-273.6
p	0.270	7182	212	-281.4
	3. u = -1.0	VMAG = 149.5	HMAG = 147.8	
π	85.4	0.323	299.8	-275.6
p	0.382	7157	299.9	-281.4
	4. u = -1.5	VMAG = 117.7	HMAG = 116.5	
π	74.0	0.519	366	-276.8
p	0.468	7131	366	-281.4

NAL Proposal No. 0073

July 2, 1970

SUPPLEMENT TO THE STANFORD-NORTHEASTERN PROPOSAL TO MEASURE u AND t-CHANNEL PROCESSES*

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Supplement to the Stanford-Northeastern Proposal to measure u and t-channel processes.

At the time of our proposal we believed that the NAL facilities group was still working on spectrometer designs. However, due to other priorities, this group discontinued work in April this year. We include in this supplement more complete designs of our own, stemming from their work and preliminary designs.[1]

Our present thinking is that the 3.5 mr beam will be the most suitable in which to place a spectrometer. The beam has high intensity, but will, if its aperture is masked down, provide high quality beams.

It appears that present budgeting and space limitations put a high premium on tight economical design. We would therefore propose for the first round of measurements, not to use point to point focussing systems, but to use point to parallel systems, as shown in Fig. 1. These would consist of a quadrupole doublet, bend magnets and proportional chamber decode planes. Such a system would be a half of the NAL preliminary design[1] and is similar to the 8 GeV Berkelman spectrometer at Cornell. The focussing elements would of course render the beam parallel and therefore make Cerenkov counter designs considerably simpler, and also keep the beam size small. We would use identical magnetic components for 75 and 200 GeV and would change the spectrometer by moving the quad pair closer or further from the target, and rotating the detector system to the new bend angle. The quads and magnet would extend for the first 30 metres only, and therefore their support carriage in order to rotate the system would only have to be as long as that used for several of the DESY spectrometers (considerably less than for the SLAC 20 GeV spectrometer), and the detectors would be mounted on a light but rigid outrigger frame extending a further 30 metres. From experience we are convinced that rotating systems of this magnitude are not costly, and are very advantageous for the experimentalist. We have discussed beam characteristics with the NAL staff and understand that with appropriate demagnification beam spots of $\frac{1}{2}$mm or less could be achieved at the target, thus cutting the magnetic bend required to achieve a given resolution by a factor two over earlier estimates, and also permitting "halving" the NAL design for the bend magnets.

At a later stage, the spectrometer system could, and almost certainly should, be extended to a point to point system. Very little would have been sacrificed by starting with the "half" system.

We have considered the use of the low field focussing and bend elements used for the accelerator to fabricate the spectrometer. It can be readily shown that the cost of a given system rises very sharply as the maximum permissible fields are decreased, and we have therefore rejected this design choice. In our SS report,[2] we considered the scaling laws on cost, solid angle etc. of spectrometers, but did not at that time explicitly write down scaling laws to include the dependence on the maximum quadrupole pole-tip fields H_{max}. Table 1 gives the universal recipe for scaling any low H_{max} system to a less expensive high H_{max} system, with the identical solid angle acceptance, resolution and focussing configuration. With the most pessimistic assumptions, the cost of any system goes inversely as H_{max} and the length of the system is proportionately decreased. We therefore propose to use as large an H_{max} as is feasible.

The present NAL design for 200 GeV is costed by NAL at $480,000 for the magnetic components for 16 μsteradians acceptance, .04% resolution (with peak quad fields of 10 Kilogauss and bend magnet fields of 15 Kilogauss). By going to the "half" system we cut this cost to $240,000 and by further increasing the peak quad and magnet fields by a factor of the order of 1.4, we should further decrease this cost to about $170,000. The length of the system would be decreased from 75 metres to 55 metres. We have not included the usual factors of 20 or 30% that almost certainly can be gained by tighter design and further playing with the parameters. The scope of this project is comparable with the small 1.6 GeV SLAC spectrometer project and much less than for the large SLAC spectrometer systems. We would expect to approach the NAL design figure of .04% resolution in $\Delta p/p$.

Table 2 lists the NAL design for 200 GeV,[1] our revised 200 GeV "half spectrometer" and accompanying 75 GeV design to give 50 microsteradians acceptance, using the identical components and carriage.

Arguments can be made for more complex spectrometer systems in order to make first-round searches for quarks, monopoles, high mass states, etc. Such searches were carried through by the Perl Group at the SLAC using a target close to the machine and an existing beam transport system as an analyser for the products. We do not believe that these experiments require a large acceptance "spectrometer" in the sense we are proposing, and would expect the use of an existing beam transport system to be satisfactory.

In the detection system we would expect to use both threshold Cerenkov counters in either coincidence or anticoincidence, and differential Cerenkov counters. For differential Cerenkov counters our present inclination is to go the BNL route of using a coincidence ring combined with an anticoincidence ring and not the CERN route of using high multicoincidences on the acceptance ring with the attendant necessity for large photon yields. By this route, without using longer counters, we could accept smaller Cerenkov angles and have larger angular separations between different particle types.

Finally we would strongly emphasize that the provision of the largest feasible solid angle devices at NAL will pay off both in the short term and long term programs. Such processes as are listed below should be easily studied if sufficient solid angle acceptances are provided.

(1) u-channel physics

(2) Large t-value measurements to test hypotheses as the Drell hypothesis of a contact interaction.

(3) Polarized target experiments. (For instance π^+p, π^-p asymmetries appear to be decreasing very slowly with energy, and should be quite measurable at energies in excess of 50 GeV.)

(4) Weak beams such as $\bar{p}$, or very high energy beams.

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TABLE 1

SCALING RECIPE FOR SPECTROMETERS TO GIVE IDENTICAL ACCEPTANCES, RESOLUTIONS AND FOCUSSING CONFIGURATIONS AT DIFFERENT SATURATION FIELDS

Elements	Old Configuration for H_{max}	New Configuration for $H'_{max} = \epsilon H_{max}$
Max. Quad field	H_{max}	$H'_{max} = \epsilon H_{max}$
Quad bores	r	r/ϵ
Quad lengths	L	L/ϵ
$B \cdot \ell$ of bend magnets	$B \cdot \ell$	$\epsilon B \cdot \ell$ *
Bend magnet apertures	w.h	$w.h/\epsilon^2$
Acceptance	Ω	Ω
Resolution	R	R
Cost of Quads	C quad	C $quad/\epsilon$ **
Cost of bend Magnets	C bend	C $bend/\epsilon$
Cost of system	C tot	C_{tot}/ϵ

* Increased to maintain identical resolutions.

** Based on the most pessimistic assumption that quad costs for the same length and bore are proportional to H^2_{max}. In actual fact the cost savings should be larger. In addition the usual assumption is made that cost is proportional to the volume of the field. (Most optimistically the quad cost for the same length and bore would go proportional to H_{max}).

TABLE 2

SPECTROMETER PARAMETERS: NAL 200 GEV PARAMETERS[1] AND PROPOSED PARAMETERS FOR A 200 GEV AND 75 GEV SPECTROMETER UTILIZING IDENTICAL COMPONENTS

NAL 200 GeV Design[1]			Proposed "$\frac{1}{2}$" NAL for 200 GeV			Proposed 75 GeV "$\frac{1}{2}$" Configuration		
Drift	12	metres	Drift	8	metres	Drift	5	metres
Quad	6	metres	Quad	4.5	metres	Quad	2.75	metres
Drift	0.5	metres	Drift	0.5	metres	Drift	7.0	metres
Quad	6	metres	Quad	4.5	metres	Quad	2.75	metres
Drift	0.5	metres	Drift	0.5	metres	Drift	7.0	metres
Bend	18	metres	Bend	10	metres	Bend	10.0	metres
Drift	5	metres	Drift	27	metres	Drift	27	metres
Quad	6.	metres						
Drift	0.5	metres						
Quad	6	metres						
Drift	12	metres						
Total	72.5	metres	Total	55	metres	Total	55	metres
$\Delta\Omega$ =	16	μster	$\Delta\Omega$ =	16	μster	$\Delta\Omega$ =	50	μster
Quad bores are 2R=10 cms with max. fields of 10 kilogauss. Bend magnet apertures are 7.5 cms by 25 cms with max. fields of 15 kilogauss.						Quad bores are 2R= 7 cms with max fields of 14 kilogauss. Bend magnet apertures are 5.5 cms. by 16 cms. with max fields of 20 kilogauss.		

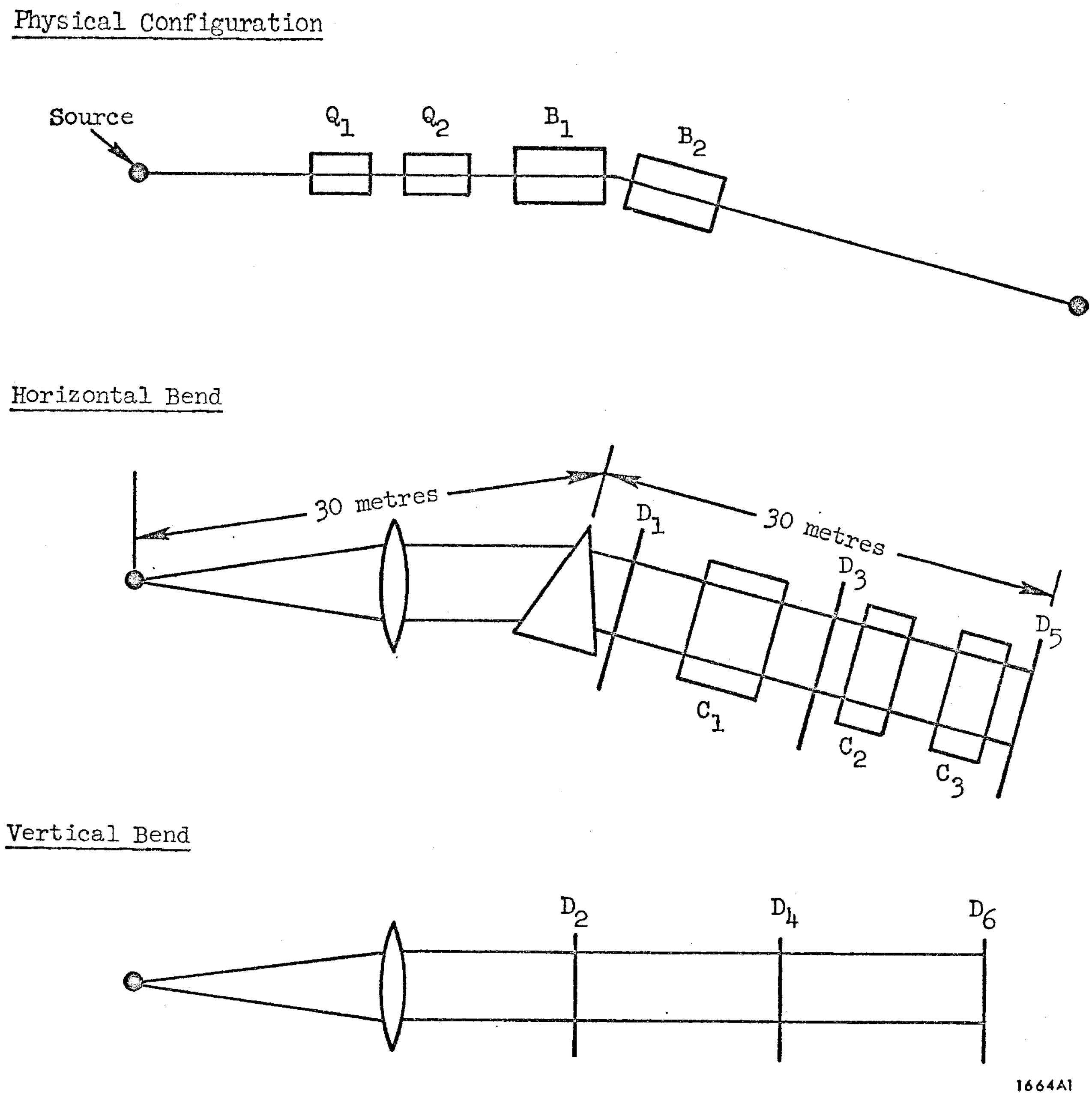

FIG. 1--Proposed "half" spectrometer configuration.

Diagrammatic representation of the proposed focussing configuration. No focal plane exists for momentum or angle, and these are determined from the Charpak proportional counter decode planes after the bend magnet. D_1 to D_6 are decode planes, C_1 and C_3 are threshold Cerenkovs, and C_2 is a differential Cerenkov.

national accelerator laboratory

July 17, 1970

PROGRAM ADVISORY COMMITTEE

We have received a correction to the supplement to Proposal 73. The third entry in the right-hand column of Table 2, p. 5 should read

"Drift 0.5 metres"

instead of

"Drift 7.0 metres."

Computer output to verify this change accompanied the letter. This output is not enclosed.

Frank

F. T. Cole
Secretary